

COMPARATIVE OSTEOLOGY OF THE FAMILY CREEDIIDAE (PERCIFORMES, TRACHINOIDEI), WITH COMMENTS ON THE MONOPHYLY OF THE GROUP¹

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ABSTRACT

A comparative osteological study of the crediid genera *Schizochirus* Waite, 1904, *Creedia* Ogilby, 1898, *Limnichthys* Waite, 1904, *Tewara* Griffin, 1933, *Crystallodytes* Fowler, 1923 and *Chalixodytes* Schultz, 1943 reveals new characters of taxonomic significance for the group, such as dentary bone not completely toothed, lower arm of posttemporal not reaching skull, anterior tip of urohyal on second or third basibranchial and posterior tip of ectopterygoid reaching posterior margin of orbit.

KEYWORDS. Perciformes, Trachinoidei, Creediidae, osteology.

INTRODUCTION

The family Creediidae presently includes seven genera and 16 nominal species of marine fishes commonly known, due to their burrowing habits, as sandburrowers. They are small, reaching a maximum length of 86mm. Creediids occur in tropical and subtropical areas of the Indian and Pacific oceans, mostly in shallow water, over sandy or gravel bottoms.

Three of the crediid genera, *Schizochirus* Waite, 1904 (type-species, *S. insolens* Waite, 1904), *Apodocreedia* Beaufort, 1948 (type-species *A. vanderhorsti*) and *Tewara* Griffin, 1933 (type-species *T. cranwellae* Griffin, 1933) are respectively, restricted to Australia, Southeast Africa and New Zealand. *Creedia* Ogilby, 1898 [type-species *C. clathrisquamis* Ogilby, 1898 = *C. haswelli* (Ramsay, 1881)] is found primarily in Australia but one of its species occurs in Japan; *Crystallodytes* Fowler, 1923 (type-species *C. cookei* Fowler, 1923) is distributed in the Central Pacific and Easter Island. The two remaining genera, *Limnichthys* Waite, 1904 (type-species *L. fasciatus* Waite, 1904) and *Chalixodytes* Schultz, 1943 (type-species *C. tauensis* Schultz, 1943) are widely distributed in the Indo-West Pacific.

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Members of the family are easily recognized by having a fleshy tip on the upper jaw which extends beyond the lower jaw, cirri bordering the lower jaw, lateral line (at least posteriorly) running near the ventral profile, and lateral line scales with a posteriorly expanded central lobe. Monophyly of the group has been suggested by NELSON (1985) and confirmed by ROSA (1993, unpublished Ph. D. thesis).

This paper encompasses a description of the osteology of *Creedia haswelli* (Ramsay, 1881) and compares that species with representatives of the remaining crediid genera. Illustrations are provided for the osteological features of this species and of *Limnichthys fasciatus*. The two aforementioned species have been chosen because they have been thought to comprise "separate lineages" of crediids (NELSON, 1985), and have been used by some authors to divide crediids into two subfamilies or families.

Some information on the comparative osteology of crediids can be found in GOSLINE (1963) and NELSON (1985); however, the following account represents the first detailed comparative study of the entire skeleton of representatives of all crediid genera. Also, previous to this study, some parts of the skeleton of crediids had not been illustrated (e.g. branchial arches, ventral side of the skull). Illustrations are provided for the various regions of the skeleton of *Creedia haswelli* (based on AMS I. 9002) and *Limnichthys fasciatus* (based on UAMZ uncatalogued, Awakominato, Chiba, Japan).

MATERIAL AND METHODS

Osteological characters were obtained mainly from cleared and stained (C + S) specimens (TAYLOR & VAN DYKE, 1985); not all specimens were cleared and stained and, in some cases, they had only been stained for bone. Because of the limited number of cleared and stained specimens available for some species, radiographs, taken by using a "Torrex 150 Radiographic - Fluoroscopic System" X-ray machine were also used. Drawings were prepared with the aid of a drawing tube attached to a Wild M5 stereomicroscope. Illustrations of *C. haswelli* and *L. fasciatus* were based respectively on AMS I. 9002 and UAMZ uncatalogued, Awakominato, Chiba, Japan. Institutional abbreviations follow LEVITON et al. (1985). Osteological nomenclature follows ROJO (1991). The osteological description follows the style used for the Uranoscopidae by PIETSCH (1989). The following abbreviations are used in the figures of the osteological characters: **An**, Angular; **APP**, Ascending process of premaxilla; **APt**, Anal fin pterygiophore; **Ar**, Articular; **B1-4**, Basibranchials 1-4; **Bh**, Basihyal; **Bo**, Basioccipital; **Br**, Branchiostegal rays; **C1-5**, Ceratobranchials 1-5; **Ch**, Ceratohyal; **Cl**, Cleithrum; **Co**, Corcaoid; **CV**, Caudal vertebra; **D**, Dentary; **Dpt**, Dorsal fin pterygiophore; **E1-4**, Epibranchials 1-4; **Ect**, Ectopterygoid; **Eh**, Epihyal; **Epi**, Epiotic; **Ep1-2**, Epurals 1-2; **ER**, Epipleural Ribs; **Ex**, Exoccipital; **Es**, Extrascapular; **F**, Frontal; **H1-3**, Hypobranchials 1-3; **Hh**, Hypohyals; **Hp**, Hypurals; **HS**, Haemal spine; **Hyo**, Hyomandibular; **I2-3**, Infraorbitals 2-3; **I2-4**, Infraorbitals 2-4; **In**, Intercalar; **Io**, Interopercle; **L**, Lacrymal; **LE**, Lateral ethmoid; **Me**, Mesethmoid; **MPP**, Maxillary process of premaxilla; **Ms**, Mesopterygoid; **Mt**, Metapterygoid; **Mx**, Maxilla; **NS**, Neural spine; **O**, Opercle; **P2,3,4**, Pharyngobranchials 2, 3 and 4; **Pa**, Parietal; **Pal**, Palatine; **Pas**, Parasphenoid; **PcR**, Pectoral radials; **PcV**, Precaudal vertebra; **Pmx**, Premaxilla; **Po**, Preopercle; **Pr**, Prootic; **PSP**, Pelvic spur; **Pt**, Pterotic; **Ptt**, Posttemporal; **PvR**, Pelvic fin rays; **PvS**, Pelvic fin spine; **Q**, Quadrate; **Sc**, Scapula; **Scl**, Supracleithrum; **So**, Subopercle; **Soc**, Supraoccipital; **Sp**, Sphenotic; **Sym**, Symplectic; **Uh**, Urohyal; **Vom**, Vomer.

RESULTS

Skull (figs. 1, 2, 4 - 6). The skull of *C. haswelli* is elongate and narrow, its maximum width (the distance between the pterotics) contained 2-2.5 times in its length. The interorbital area is very narrow, its least width contained **ca.** 15-16 times in the maximum distance between the pterotics. Most of skull elements, posterior to infraorbital area (both on the dorsal and ventral surfaces), overlap with their adjacent bones. The bones are smooth, covered by a layer of skin, and virtually devoid of crests. There are five relatively large orifices (the median one elliptic-shaped, the lateral ones rounded) on the anterodorsal surface of the frontals.

The remaining genera have a less elongate and posteriorly wider skull, its maximum width (at the level of the pterotics) contained 1.5-2 times in its length. In *Schizochirus* each frontal has one shallow, median orifice on the anterodorsal surface, one laterally placed, and two smaller ones on the anterolateral corner (posterior to the orbits). Two elliptic pores are present at the posterior tip of the interorbital bridge. *Limnichthys* has one or two rounded pores on the interorbital region (more posteriorly placed than the one in *Schizochirus*); each frontal also bears an anterolateral, rounded orifice (posterior to the orbit). In *Tewara*, each frontal has a comparatively large, rounded median orifice, and an anterolateral one about half the size of the median one. Each frontal bone of *Crystallodytes* has a median orifice (posterior to the orbit) and a slightly smaller one on the anterolateral surface. In *Chalixodytes* the orifices are similar to the ones found in *Crystallodytes*, but the median one is about the same size as the lateral one. In *Apodocreedia*, there are two anterolateral pores on each frontal, and a median one, at the level of the posterior margin of the orbit; the median pore is reduced in size, being **ca.** three times smaller than the lateral ones.

Ethmoid Region (figs. 1, 2, 9, 12). The vomer has a broadened head with a rounded anterior margin and a tapered posterior strut; each side of the posteroventral margin of the head has a pointed posteriorly directed projection. The vomer abuts the head of the maxillae anteroventrally, the palatines lateroventrally, the lateral ethmoids dorsolaterally, and the mesethmoid dorsally. Posteriorly, the vomer is firmly attached to the parasphenoid. The posterolateral margin of the vomerine head bears 2-4 small canine-like teeth. The mesethmoid is rounded anteriorly, with a median protrusion on its dorsal surface; posteriorly, the bone is tapered, its tip being inserted between the anterior end of the frontals. Dorsomedially the mesethmoid bears a longitudinal, narrow ridge on the posterior half of the bone, its posterior tip lying between the anterior end of the frontals. Dorsolaterally, the mesethmoid supports the nasal; ventrally it is firmly attached to the head of the vomer. The lateral ethmoids delimit the anterior margin of the orbits; each has moderately broad lateral projections about one third the length of the nasal, a median circular foramen and a posterior sharp tripartite process. Each lateral ethmoid contacts the mesethmoid medially, the lacrymal laterally, the palatine ventrolaterally, the mesopterygoid posteroventrally and the frontal posterodorsally. The nasals are elongate and tubular; each has an expanded triangular anterior end and extends from the anterior tip of the frontal to the head of the maxilla. They are

supported by connective tissue, and loosely connected to the mesethmoid medially, the lateral ethmoid posterolaterally and the vomer and palatine ventrally.

The ethmoid region of *C. haswelli* differs from the one found in the other genera as follows: in *Schizochirus* the anterior margin of the vomerine head is blunt; laterally it is slightly concave and bears a cluster of conical teeth. The lateral ethmoid foramen is larger, the nasals have a rounded tip and bear a lateral flange. The mesethmoid is similar in shape, but the posterodorsal projection is smaller. The nasals greatly vary in shape among creediid genera: they are somewhat J-shaped (in *Limnichthys* and *Crytallodytes*) crescent-shaped (in *Tewara*), L-shaped (in *Chalixodytes*) and S-shaped (in *Apodocreeidia*). The anterior tip of the nasal is rounded or slightly rounded in the aforementioned genera. *Limnichthys*, *Chalixodytes*, *Crystallodytes* and *Apodocreeidia* lack the posteriorly directed vomerine projection, and all but *Tewara* possess a posterolateral projection on the dorsal surface of the vomer, (smallest in *Apodocreeidia*) where the teeth are located. The number of vomerine teeth is usually low in creediids (between two and six teeth), but some specimens of *Limnichthys fasciatus* can have more than ten.

Orbital Region. (figs. 1, 2, 7, 10, 13, 17). Each orbit is delimited by the lateral ethmoid anteriorly, the frontal mid and posterodorsally, the parasphenoid ventrally, the sphenotic posteroventrally; the laminar mesopterygoid shelf forms the floor of the orbit. Two sclerotic ossicles support the eyeball; a basisphenoid is absent. The frontals are narrow anteriorly and expanded laterally behind the orbits; they make up approximately 50% of the dorsal surface of the skull. Anteriorly each frontal has a forked tip, which meets the posterior end of a nasal bone and contacts the posterior end of the respective lateral ethmoid. Posterodorsally (behind the orbit) the frontals partially overlap the parietals, supraoccipital, and sphenotics. Posteroventrally, the frontals contact a medially directed flange of the sphenotics. Immediately before the point where the frontals fan out, there is a single dorsal interorbital pore; the anterior margin of the broadened portion of the frontals has a ventrally directed shelf, which delimits the posterior margin of the orbit; two large dorsal pores are present on the broadened base of each frontal. The parasphenoid is elongate, narrow anteriorly, broadened medially and tapered posteriorly. Midposteriorly each side has a wing which contacts the prootic and pterosphenoid dorsolaterally; posteriorly, the parasphenoid partially, overlaps the prootic and basioccipital. Midventrally, each side of the parasphenoid bears a pointed anteriorly directed process, at the base of the parasphenoid wing. Each infraorbital series consist of four canal bones: the lacrymal is the largest and somewhat triangular; anteriorly it articulates with the lateral ethmoid and partially covers the head of the maxilla; posteriorly, it has a short projection which loosely contacts the second infraorbital; the second infraorbital is elongate and tube-like; posteriorly, it is firmly attached to the third infraorbital; the third infraorbital is approximately of the same length as the second one along the orbital margin, but it possesses a ventral laminar shelf. A small, incomplete ring-like fourth infraorbital is firmly attached to the sphenotic. The sphenotics are paired canal bones, firmly attached to the anterolateral surface of skull. Ventrally they bear a large flange which overlaps the part of the parasphenoid ascending wing.

In the other creediid genera the frontals do not bear an anterior shelf, and its anterior end is not forked or slightly forked; in *Schizochirus* each frontal bears two pores anterolaterally and two midanteriorly. There are two pores in the interorbital area of *Schizochirus* and some *Limnichthys*. The anteriorly directed pointed projection of the parasphenoid is shorter in *Limnichthys*, *Tewara* and *Crystallodytes*. The infraorbital series of *Schizochirus* considerably differs from the one found in *C. haswelli* and remaining creediids: the lacrymal has a transverse median groove and lacks the posteroventral projection; the second infraorbital is squarish, the third lacks the ventral shelf; the fourth is larger, cone-shaped and more loosely attached (the fourth infraorbital is also cone-shaped in *Limnichthys* and *Tewara*). In *Limnichthys*, *Tewara*, *Chalixodytes*, *Crystallodytes* and *Apodocreedia* the second infraorbital is smaller than in *C. haswelli*.

Otic Region (figs. 1, 2, 4, 5). The parietals are widely separated from one another, and form part of the dorsolateral surface of the skull. Anteriorly each is overlapped by the frontal; medially they overlap the supraoccipital; laterally each contacts the pterotic, and posteriorly the epiotic. The epiotics are widely separated from one another, and form part of the posterodorsal surface of the skull. Each epiotic contacts the parietals anteriorly, the supraoccipital medially, and the pterotic laterally; each epiotic has a shallow recess where the dorsal arm of the posttemporal attaches. The supraoccipital forms the dorsomedial area of the skull and bears a very small median crest on its posterior surface. The supraoccipital is overlapped by the frontals anteriorly and by the parietals laterally; it contacts the epiotics posterolaterally and slightly touches the suture along the anterior margin of the exoccipital posteriorly. Each prootic is relatively large and has a median foramen. It comprises approximately one half of the lateroventral surface of the skull; it overlaps the parasphenoid anteriorly and medially; it is overlapped by the intercalar posteriorly; it also contacts the pterotic and sphenotic laterally. The posterior margin of the prootic comes very close to the anterior margin of the basioccipital but there is no contact. The sphenotics are adjacent to the anterolateral surface of the skull; dorsally each sphenotic partially overlaps the frontal and parietal; ventrally each barely contacts the parasphenoid wing and prootic; posteroventrally the sphenotic contacts the prootic. The anterior head of the hyomandibula tightly fits into a notch located at the point of contact between the sphenotic and prootic. The pterotics are the posteriormost bones on the lateral surface of the skull; dorsally each has a canal-like structure that meets the canal of the lateral extrascapular; in lateral view, each contacts the sphenotic anterodorsally, slightly touches the parietals and contacts the outer margin of the epiotic medially; each pterotic also contacts the prootic, is partially overlapped by the intercalar ventrally, and contacts the exoccipital posteriorly. Each intercalar is roughly square in shape, and most of its flattened surface covers the adjacent bones. Anteriorly it partially overlaps the prootic, laterally the pterotic, and midposteriorly the basioccipital. A central area of the intercalar receives the ligament that connects the short ventral arm of the posttemporal to the skull.

Main differences: the degree of overlap between the supraoccipital and the parietals is markedly increased in *Crystallodytes*; the supraoccipital crest is reduced

to a stub in *Chalixodytes* and is more triangular and pointed in *Crystallodytes*.

Basicranial Region (figs. 2, 5). The basioccipital is roughly fan-shaped and forms the midposterior portion of the ventral surface of the skull. Anteriorly its broadened margin partially overlaps the parasphenoid; dorsally it meets the exoccipitals; laterally it partially overlaps the intercalar; posteriorly the tapered basioccipital provides the articular surface for the first vertebra. The exoccipitals lie immediately dorsal to the posterior portion of the basioccipital; in ventral view, each has a circular foramen on its outer margin. The exoccipitals contact the pterotic and intercalar anteriorly; dorsally they contact the epiotic. In *Limnichthys*, *Chalixodytes* and *Crystallodytes* the midanterior margin of the basioccipital is notched; in the other genera it is like it is in *C. haswelli*.

Jaws (figs. 3, 6, 8, 9). The premaxillae are elongate, their heads being widely separated from one another; each premaxilla has an elongate posteriorly directed ascending process which extends slightly beyond the anterior margin of the mesethmoid; the tip of the ascending process lies on a relatively large, roughly squarish cartilaginous area. Each premaxilla also has a conspicuous rounded articular process and a maxillary process (postmaxillary process of PIETSCH, 1989). The maxillary process is relatively narrow and convex in dorsal profile. A cluster of approximately four to six large, canine-like teeth is present on the base of the articular process of each premaxilla; ca. 10-12 canine-like teeth, slightly smaller than the ones on the base of the articular process, are present along each maxillary process. The maxillae are rod-like, with an expanded head and a broadened forked posterior tip. The maxillary head has two anteriorly directed projections, which tightly articulate with the premaxillary articular process laterally and medially. Each maxilla also contacts the respective palatine anteriorly, the lacrymal dorsally, and the premaxilla posteroventrally; the anterior tip of the nasal bones contacts the maxillary head laterally. The forked, posterior tip of the maxilla extends to the level of the second infraorbital. The dentaries are arrow-shaped, toothed, with an anterodorsal knob. The dorsal arm of the dentary is slightly smaller than the ventral one, and has a dorsally directed process on its posterior tip. The outer surface of each dentary has 2-3 pores anteroventrally and a shallow, relatively large pit anterodorsally. Each dentary bears approximately 25-31 canine-like teeth; no teeth on symphysis or posterior portion of dentary. The articulars consist of an anteriorly directed pointed process which fits between the arms of the dentary, a dorsal anteriorly directed pointed projection, a ventral shelf, and a posterodorsal projection, which receives the quadrate. Each articular has a membranous moderately splintered area along its ventral margin. The angulars are relatively small, tightly fitted between the posterior tip of the articular, the anterior margin of the interopercle and the ventral tip of the preopercle.

Main differences: teeth are absent from the base of articular process of the premaxilla in all other creediid genera except *Schizochirus* (present in all *Creedia* species). Heads of the premaxillae are separated from one another in *Schizochirus*, and, to a lesser degree, in *Limnichthys*; in the remaining genera the premaxillary heads meet medially. The ascending processes of the premaxillae are fused

together in *Apodocreedia*. The posterior end of the maxilla is not forked in the other creediids, except for *Schizochirus*. The process on the articular bone is slightly smaller in *Limnichthys* and *Tewara*, reduced to a stub in *Apodocreedia* and absent in *Crystallodytes* and *Chalixodytes*. The maxillary process is absent in the other genera, except for *Schizochirus*. There are more teeth on each premaxilla (between 23 and 50) and usually more teeth on the dentary (between 20 and 45) in the remaining genera.

Palatine Arch (figs. 7, 9, 10, 12). Each palatine is an elongate, curved bone; anteriorly it is tapered and posteriorly it is broadened, with a forked tip. It contacts the head of the respective maxilla anteriorly, is firmly attached to vomerine head projections midanteriorly, to the lateral ethmoid medially and to the mesopterygoid posteriorly. The anterior tip of the ectopterygoid lies in the angle formed by the forked posterior end of the palatine. About 6 or 7 small canine-like teeth are present on the posterior half of the palatine (palatine teeth were absent in one of the cleared and stained specimens). The ectopterygoids are rod-like with a fan-shaped tip. Anteriorly each ectopterygoid attaches to the outer arm of the forked posterior end of the palatine; posteroventrally its small triangular tip is firmly attached to the lower corner of the metapterygoid and barely touches the upper corner of the quadrate along its anterior margin. The ectopterygoid does not make contact with any other bones. The mesopterygoids are elongate, laminar, somewhat concave, with a forked anterior end, and a slightly upturned tapered tip; they support the eyeballs ventrally and posteriorly. Each mesopterygoid is firmly attached to the posterior projection of the vomer anteriorly, contacts the lateral ethmoid anterodorsally and the palatine laterally. The median and posterior regions of the mesopterygoids do not contact any bones. The metapterygoids are relatively large, somewhat triangular and with a small transversal crest on the dorsal surface; each metapterygoid contacts the hyomandibula posterodorsally and the ectopterygoid anteriorly. The ventral margin of each mesopterygoid closely approaches the dorsal margin of the quadrate, but the two bones only contact through a narrow posterodorsal projection of the quadrate. The remaining of the dorsal surface of the quadrate and the ventral surface of the metapterygoid are separated by cartilage.

Main differences: the palatine is without teeth and without a forked posterior end in the other genera, except for *Schizochirus*. In *Crystallodytes* the palatine bears two crests; *Schizochirus* has one medial crest; the head of the palatine is more perpendicular to the shaft of the bone in the other creediid genera. The metapterygoid crest is absent in *Schizochirus*, and it is most pronounced in *Tewara* and *Limnichthys*; the mesopterygoid tip is more upturned, partially enclosing the posterior margin of eyeball in *Limnichthys*, *Tewara* and *Chalixodytes*; in *Crystallodytes* and *Apodocreedia* it extends farther up and projects onto the dorsal surface of the orbit. The triangular tip of the ectopterygoid is larger in all genera, especially in *Schizochirus*; the ectopterygoid rod is wider in *Schizochirus*. There is less contact between the ectopterygoids and the palatines in the remaining genera, except for *Schizochirus*.

Hyoid Arch (figs. 3, 6, 24-26, 28-30). Each hyomandibula is roughly rectangular

and has three distinct heads along its dorsal margin; the anteriormost head ventrally bears a canal and tightly articulates with the sphenotic and pterotic; the median head tightly articulates with the pterotic and the posterior one tightly fits in an articular fossa on the anteroventral surface of the opercle. Ventrally each hyomandibula is partially overlapped by the metapterygoid; posteriorly it partially covers the preopercle. The symplectics are somewhat elongate and triangular and tightly fitted into the inner surface of the quadrate. Dorsally each is separated from the hyomandibula by cartilage; posteriorly each partially overlaps the lower corner of the metapterygoid. The quadrates are triangular, with an elongate, dorsally directed posterior projection. Each contacts a small area of the metapterygoid dorsally, the articular ventrally and the symplectic midventrally. Each quadrate barely touches the ectopterygoid anteriorly, and abuts the preopercle posteriorly. Each hypohyal consists of a dorsal and a ventral element. The dorsal one is a somewhat triangular cap which lies on top of the larger ventral element; it contacts the basihyal midanteriorly and the basibranchial 1 midposteriorly. The ventral hypohyal has an elongate posteriorly directed projection which is firmly attached to the ceratohyal; medially the bone contacts the basibranchial 1. The ceratohyals are elongate, slightly broadened on both ends, and have a small projection midventrally. Anteriorly each contacts the ventral hypohyal and it is separated from the dorsal hypohyal by cartilage. Ventrally each ceratohyal supports five branchiostegal rays; posteriorly each is attached to the epihyal via an elongate projection. The triangular epihyals contact the ceratohyal anteriorly and the interhyal posterodorsally; the posterior end of each epihyal tightly fits into a depression on the inner surface of the interopercle. Each epihyal supports two branchiostegal rays anteroventrally. The interhyals are dorsally directed relatively small and narrow bones; anteriorly each articulates with a small depression at the tip of the epihyal; each interhyal also contacts the inner surface of the interopercle medially and the preopercle posteriorly. There are seven branchiostegal rays attached via their anterior heads to the ceratohyal and epihyal. The first three are attached to the anteroventral surface of the ceratohyal; the fourth is ventrolaterally placed; it lies on a groove at the base of the ventral projection of the ceratohyal; branchiostegal ray 5 is ventrolaterally placed on the posterior end of the ceratohyal. Branchiostegal rays 6-7 are attached to the ventrolateral surface of the epihyal. The first two branchiostegal rays are slightly smaller than the other ones. The basihyal is thin and elongate, with a small cartilage attached to its anterior end. Posterolaterally the basihyal contacts the dorsal hypohyals. Posteriorly it contacts the basibranchial 2 via cartilage. The urohyal is rod-like anteriorly, laterally compressed and dorsoventrally expanded posteriorly. It extends from the level of second basibranchial to slightly beyond the anterior end of the ceratobranchial 5. The urohyal contacts two bones: anteroventrally its head articulates with the anterior end of the basibranchial 2 via small lateral projections. Anterodorsally it is attached to the left and right hypohyals via a ligament.

Main differences: in *Schizochirus*, the branchiostegal rays are wider, and the urohyal is anterolaterally expanded; the basihyal is posteriorly wider in *Limnichthys*, *Tewara* and *Schizochirus*. The urohyal is anteriorly forked in *Limnichthys*, *Tewara*, *Crystallodytes* and *Chalixodytes*, and has a laterally

expanded head in *Apodocreedia*. It is shorter in *Limnichthys* and *Tewara*, and dorsoventrally expanded in those two genera and *Schizochirus*; in *Crystallodytes* and *Apodocreedia* the urohyal is tapered posteriorly. The anterior tip of that bone lies on the anterior end of basibranchial 2 in *Schizochirus* and *Limnichthys*, on the mid-portion of basibranchial 2 in *Tewara*, and on the posterior end of basibranchial 2 in *Crystallodytes* and *Chalixodytes*. In *Apodocreedia*, it lies on the anterior tip of basibranchial 3. In *Limnichthys*, hypobranchial 3 bears two anterolateral projections. The hypohyals of *Crystallodytes* and *Chalixodytes* are reduced in size. There are six branchiostegal rays on the ceratohyal and one on the epihyal in *Crystallodytes*, *Chalixodytes* and *Apodocreedia*.

Opercular apparatus (figs. 3, 6). The bones of the opercular region of *C. haswelli* are thin and unsculptured; most of them are splintered along their free margins. The preopercle is a narrow, crescent-shaped bone, tightly fitted between the quadrate, metapterygoid and hyomandibula (along the anterior margin) and the interopercle and subopercle (along the posterior margin). Its dorsal surface bears a canal which is part of the acoustico-lateralis system. Some parts of the free margin of the preopercle are very faintly splintered. Each interopercle is roughly triangular; its ventral margin being the widest. It articulates anteriorly with the posterior margin of the preopercle, dorsally with the lower corner of the opercle and posteriorly with the anterior margin of the subopercle. The anterior margin of the interopercle has a very shallow notch, which receives the angular bone; its lower half is splintered. The subopercles are roughly rectangular, with a slightly concave anterior margin, which attaches to the posteroventral margin of the opercle. Anteroventrally each contacts the interopercle. **Ca.** 2/3 of the surface of the subopercles is splintered. The opercles are triangular, their anterior margin the widest. Each contacts the preopercle anteriorly, the interopercle anteroventrally, and the subopercle ventrally. An articular fossa, which receives one head of the hyomandibula, is anteriorly placed on the ventral surface of the opercle. The free margin of the opercle is entire.

Main differences: the free margin of the preopercle of the remaining genera has no splintering (except in *Schizochirus*); the opercle is smaller in *Apodocreedia* and *Crystallodytes* and it is splintered in the former genera and in one of species of *Crystallodytes* (some splintering of the opercle was observed in a few C+S specimens of *Limnichthys polyactis* Nelson, 1978 and *L. fasciatus*). The interopercular anterior notch is more pronounced in the remaining genera (except for *Schizochirus*).

Branchial Arches (figs. 23, 27). The four basibranchials consist of three bony and one cartilaginous elements, separated from each other via cartilage. Basibranchial 1 is the shortest of the three bony elements; its anterior end is wedged between the posterior ends of the basihyal and hypobranchial 1; basibranchial 2 is hour-glass shaped and slightly larger than basibranchial 1; basibranchial 3 is narrow and elongate; its tip lies between the hypobranchials 3. Basibranchial 4 is a small, cartilaginous element situated between the anterior tips of ceratobranchials 3 and 4. There are three pairs of hypobranchials: hypobranchial one is the largest; midanteriorly each contacts the anterior end of the basibranchial 2; posteriorly it

is separated from the ceratobranchial 1 by cartilage. Hypobranchials 2 are about half the size of hypobranchial 1; anteriorly each is separated from the tip of the basibranchial 2 by cartilage; posteriorly it is separated from the anterior end of the ceratobranchial 2 by cartilage. Hypobranchials 3 are the smallest in the series; midanteriorly they contact the posterior end of the basibranchial 3; posteriorly they are separated from the ceratobranchial 3 by cartilage. There are five pairs of ceratobranchials: ceratobranchials 1-4 are elongate, approximately of the same size, and articulate with their respective hypobranchials and epibranchials. Ceratohyals 5 are slightly smaller than ceratohyal 1-4 and bear about 3-4 rows of conical teeth on their antero and middorsal surface. The four pairs of epibranchials attach to their corresponding ceratobranchials; epibranchials 1 and 2 approximately of the same size, have a medial process and articulate respectively with the anterior and posterior ends of the pharyngobranchials 2. Epibranchials 3 are anteriorly broadened, smaller than the preceding ones and have a small process on its upper corner. Anteriorly each epibranchial 3 contacts pharyngobranchials 3 and 4; epibranchials 4 are slightly longer and narrower than the others; anteriorly each articulates with pharyngobranchial 4. Pharyngobranchial 1 is absent; pharyngobranchials 2 are relatively small toothed plates, which medially articulate with a projection of pharyngobranchial 3; pharyngobranchials 3 are the largest elements of the series, and bear numerous teeth along most of its surface, but none on the lateral projection; each articulates with the epibranchials 2 and 3. Pharyngobranchials 4 are about the same size as pharyngobranchial 2 and also bear conical teeth; each articulates with epibranchials 3 and 4. Toothplates with several conical sharp teeth are present along the inner surface of each ceratobranchial 1, outer and inner surfaces of ceratobranchials 2 and 3, and outer surface of ceratobranchials 4. The inner surface of hypobranchial 1 and the outer surface of hypobranchial 2 bear two small plates, similar to the ones found along the inner surface of ceratobranchials 1. Each epibranchial 1 bears two small plates with spiny teeth along their ventral surface; epibranchials 2 have a combination of larger, more flattened plates and a few smaller ones along their dorsal surface; a single small plate is present along their ventral surface. Epibranchials 3 have larger flattened plates along their outer and inner surfaces; they also bear a few smaller plates along their dorsal and ventral surfaces. Each epibranchial 4 bears a small plate along its inner surface. The outer surface of hypobranchials 1 and ceratobranchials 1 bear gill rakers, shaped as large flattened plates with short conical teeth.

Main differences: in *Schizochirus*, there is an incomplete row of enlarged teeth on the inner margin of ceratobranchial 5, the teeth on pharyngobranchials are larger and hypobranchial 3 is larger, with a more prominent dorsolateral projection. The conspicuous dorsolateral projection is also found in *Limnichthys* and *Tewara*. In the remaining genera, that projection begins to expand downward (*Crystallodytes*) and becomes much curved down (*Chalixodytes* and *Apodocreeidia*). In *Tewara* there are less teeth on pharyngobranchial 3 and there is less contact between hypobranchial and basibranchial 3. In *Chalixodytes*, *Crystallodytes* and *Apodocreeidia*, the contact between hypobranchial and basibranchial 3 is further diminished, most markedly in *Apodocreeidia*. The three latter genera also have a

more cartilaginous basibranchial 3 than the other creediids.

Axial skeleton (figs. 15, 18, 31, 34). There are 41-43 vertebrae (excluding the urostyle), the first 14-16 being precaudal; the first caudal vertebra has a much larger haemal spine than the last precaudal. The neural spines of most vertebrae are of the same length, except for the one on the penultimate vertebra, which is much shorter than the preceding ones. Haemal spines become noticeable around vertebrae 8 or 9, and become greatly enlarged around vertebrae 15-17; the last haemal spine is wider than the preceding ones. 29-33 epipleural ribs are present from vertebrae 1; pleural ribs are absent. The first 15-17 ribs have a slightly expanded head, are ventrally directed and larger than the following ones. The remaining ribs get progressively smaller and more posteriorly directed; most ribs are placed on the midline of the respective vertebrae; the last 3-4 ribs are greatly reduced in size. The only autogenous element of the hypural plates is the parahypural, the other elements being fused. A hypurapophysis is absent. Two relatively elongate epurals are present, the epural 1 being the smallest; uroneurals are absent. There are eight or nine branched caudal rays.

There are 38 vertebrae in the clear and stained specimen of *Schizochirus*. NELSON (1985) gives a range of 36-41, including the urostyle (J.S. NELSON, personal communication), the first 14 with wider neural spines; there are 12 precaudal vertebrae in that genus, its haemal spines longer, interdigitating with 1/4 - 1/2 of pterygiophores. There are 28 ribs, starting from vertebra one, most of them placed low on the vertebrae. First 13 ribs wider, all posteriorly directed. Nine branched caudal rays are found in *Schizochirus*. In *Limnichthys*, there are 37 to 45 vertebrae, 21-27 spine-like ribs, without expanded head, the ones on caudal region smaller; 14-16 precaudal vertebrae are present, the caudal vertebrae bear an anteroventral projection. The two to five last neural spines are squarish, not spike-like, and the last neural spine is not reduced; the two to six last haemal spines laterally expanded. There are eight branched caudal rays and one or two epurals in *Limnichthys*. *Tewara* has 50-53 vertebrae (NELSON, 1985 gives a range of 49-55), 14 being precaudal. The 21-22 ribs are spine-like, the four to five last neural spines are squarish, last neural spine not reduced; the four to five last haemal spines laterally expanded; the caudal vertebrae bear an anteroventral projection. Eight branched caudal rays and one epural are present. There are 50-58 vertebrae in *Crystallodytes* (NELSON, 1985 gives a range of 48-60), 24-25 being precaudal; the caudal vertebrae bear an anteroventral projection. The 45 ribs are spine-like, the haemal spines are shorter, and the last neural spine not reduced; eight branched caudal rays and one epural are found in *Crystallodytes*. *Chalixodytes* possesses 56-59 vertebrae, 23-24 being precaudal; the caudal vertebrae bear an anteroventral projection; the 23 ribs are spine-like, the last neural spine is not reduced, and the haemal spines are shorter. Eight branched caudal rays and one epural are present in that genus.

There are 55-58 vertebrae in *Apodocreedia*, of which 23 are precaudal; anteroventrally, the vertebrae bear a process, similar to the one found in *Crystallodytes*, *Limnichthys*, *Tewara* and *Chalixodytes*. The 41 to 42 ribs are spine-like, the four to six anteriormost neural spines are wider; there are eight branched

caudal rays and one reduced epural in *Apodocreedia*. In this genus, the dorsal and ventral hypural plates are partially fused together.

Dorsal and Anal Fins (figs. 32, 33, 35, 36). There are 12-15 dorsal pterygiophores with two elements (except for the last one which only has the proximal element) and supporting one unbranched ray; the first dorsal pterygiophore is inserted between neural spines 21 and 22; in two clear and stained specimens, it bears a dorsal anteriorly directed crest; the remaining dorsal pterygiophores are elongate with an expanded head. The ventral end of each proximal element of the dorsal pterygiophores interdigitates with approximately $1/2$ - $1/3$ of the length of the respective neural spine. The dorsal rays are biserial, segmented and approximately of the same length, except for the last one, which is much smaller. The anal fin consists of 23 or 24 unbranched rays, supported by 22 or 23 pterygiophores (the first anal pterygiophore bears two ventral projections and supports two rays); there are four anal pterygiophores anterior to the first caudal vertebra. All anal pterygiophores but the last one consist of two elements (only the proximal element is present on the last one); all pterygiophores opposite the caudal vertebrae interdigitate with approximately $1/3$ - $1/4$ of the respective haemal spines. The anal rays are of the same length, except for the last one, which is much smaller.

Main differences: *Schizochirus* has 20 dorsal pterygiophores, the first one with laminar flanges both anteriorly and posteriorly to the main axis of the proximal pterygiophore; the next 16 pterygiophores only have the posterior flange, the last three do not bear flanges. The medial element of the dorsal pterygiophore has an anteriorly directed projection which tightly fits between the anterior tips of the rays. The first dorsal pterygiophore is inserted between neural spines 14 and 15; all pterygiophores interdigitate with $1/4$ - $1/3$ of the length of the neural spines. The anal fin consists of 20 (in the C+S specimen) biserial, segmented branched rays, supported by 19 pterygiophores. All pterygiophores but the first one have flanges anterior and posterior to the main axis of the proximal element; the flanges become progressively smaller caudad; the anterior ones are flattened ventrally and articulate with the dorsal surface of the medial element of all but the last anal pterygiophore (which only possesses the proximal element). All anal pterygiophores interdigitate with $1/3$ - $1/2$ of the length of the respective haemal spines. The first four anal pterygiophores strongly converge to the last precaudal vertebra. There are 20-33 dorsal pterygiophores in *Limnichthys*, the first one being inserted between neural spines 11 and 12 or 13 and 14; it bears two small anteriorly directed stubs. The anal fin consists of 22-34 rays, supported by 21-33 pterygiophores; the first 6-7 pterygiophores slightly converge to the last precaudal vertebra. The dorsal fin of *Tewara* has 34-36 pterygiophores; the first one is inserted between neural spines 13 and 14 and bears a small stub. The anal fin consists of 36-39 rays supported by 35-38 pterygiophores. The first six anal pterygiophores slightly converge to the last precaudal vertebra. *Crystallodytes* has 30-39 dorsal pterygiophores, each supporting one ray. The first pterygiophore is inserted between neural spines 16 and 17. Interdigitation between neural spines and dorsal pterygiophores mostly around vertebrae 45-48; after that point, the pterygiophores barely reach the neural spines. The anal fin consists of 35-40 rays, supported by 34-39 pterygiophores. In

Chalixodytes there are 35-40 dorsal pterygiophores. The first one is inserted between neural spines 17 and 18; the anal fin consists of 36-40 rays, supported by 35-39 pterygiophores. The interdigitation between neural and haemal spines and respective pterygiophores is limited to the tips of those elements or interdigitation does not occur. *Apodocreedia* has 35-39 dorsal fin rays; the first pterygiophore is inserted between neural spines 14 and 15 or 16 and 17; the anal fin consists of 32-36 rays, supported by 31-35 pterygiophores. Both dorsal and anal pterygiophores are positioned more horizontally than in the other genera and only around vertebrae 39-41 a very limited interdigitation occurs between those elements and their respective neural and haemal spines.

Pectoral and Pelvic Girdles and Fins (figs. 14, 16, 19-22). Each posttemporal is a flat, canal bone, with two dorsal anteriorly directed processes, which attach the pectoral girdle to the skull. The dorsal process is wider and larger than the ventral one; it attaches to the posterodorsal surface of the epiotic. The ventral arm is about $\frac{2}{3}$ the length of the dorsal one and connects the intercalar via ligament. Anteriorly each posttemporal contacts the posterior end of the extrascapular canal. The posterior end of each posttemporal is partially overlapped by the supracleithrum. Each supracleithrum is a flat elongate bone which partially overlaps and firmly attaches to the dorsal surface of the cleithral ridge. The cleithra are somewhat L-shaped with a ridge along their outer surface; the dorsal end of each cleithrum has three spines: two are covered by the respective supracleithrum; the third is the smallest, posteriorly directed; ventrally, it contacts the scapula near the scapular foramen. A very small and narrow postcleithrum is loosely attached to the ventral surface of the radials. Each scapula and coracoid attach to the cleithral shelf; posteriorly each scapula is fused to radial 1, which supports 4-5 pectoral fin rays. Midanteriorly each scapula bears a relatively small foramen, not covered by the cleithrum. The coracoids are separated from the cleithrum by cartilage; both ends of each coracoid attaches to the cleithrum, but a small median area does not contact that bone. Posteriorly the coracoids are fused to three radials, which support 8-10 pectoral fin rays. The four radials are partially fused to one another and to the respective scapula and coracoid, except for the third one, which is separated from the coracoid via cartilage. The basipterygia are separated from each other, are concave and form a bowl-shaped pelvis. Each basipterygium contacts the pectoral girdle via an anterolateral flange which is firmly attached to a ventrally directed cleithral projection. Laterally the basipterygia bear an anteroposterior shelf which possesses a small medially directed spine (pelvic spur) at its tip. The anterior margins of the basipterygia are joined by cartilage; a small cartilage joins the two basipterygia midposteriorly. One spine and four unbranched rays articulate with the posterior margin of each basipterygium.

In *Schizochirus* the ventral arm of posttemporal is about $\frac{1}{2}$ the length of the dorsal one; the cleithra are less L-shaped (i.e., straighter), the cleithral dorsal spines are less developed, the ventral spine being the largest; there are two postcleithra, the upper one rectangle-shaped, the lower one broader dorsally and tapered ventrally; the scapular foramen is larger, reaching the ventral surface of that bone; the radials are more separated from one another, $1\frac{1}{2}$ radials are fused to the scapula, the remaining half of the second radial only attaches to the third radial;

radials 1 and 2 support nine pectoral rays; the coracoid does not contact the third radial, but is fused to the fourth one; radials 3 and 4 support seven pectoral rays. The uppermost pectoral ray is splintlike and unbranched, the upper rays are shorter and narrower than the middle ones; most rays are branched and markedly segmented. The basipterygia are larger, with the anterior margins meeting medially; a posteriorly directed process is present midposteriorly. One spine and five branched rays articulate with each basipterygium. The pelvic spur is more robust but shorter. The lower arm of the posttemporal of *Limnichthys* is **ca.** $1/2$ - $2/3$ the length of dorsal one. The contact between coracoid and cleithrum is reduced, the contact being made via a sharp process (in some specimens, the process is absent); five to six rays articulate with the coracoid, seven to nine with the scapula; postcleithra are absent. The basipterygia of *L. polyactis* possess a posteriorly directed process, which is not found in the other species of *Limnichthys*. A squarish projection connects the cleithrum to the respective basipterygium in *L. polyactis* and *L. rendahli* Parrott, 1958; the pelvic spur is longest in *L. fasciatus*. In *L. nitidus* Smith, 1958, its is usually wider than in *L. fasciatus*, and longer than the one found in *L. polyactis* and *L. rendahli*. One spine and five rays articulate with each basipterygium. In *Tewara*, the ventral arm of the posttemporal is **ca.** $1/3$ the length of the upper one. The orifice between the coracoid and cleithrum is slightly larger; six rays articulate with radials 3 and 4; six articulate with radials 1 and 2; the cleithral shelf is confined to the upper half of that bone. As in *C. haswelli*, the pelvic spur is small; the basipterygia posteriorly bear a process. One spine and five rays articulate with each basipterygium. The ventral arm of the posttemporal of *Crystallodytes* is about $1/3$ the length of the dorsal one; the scapular foramen is concealed by the cleithral shelf, the area separating the coracoid from the cleithrum is smaller; six rays articulate with radials 3 and 4, eight with radials 1 and 2. The cleithral shelf is confined to the upper half of that bone. The pelvic spurs are large and meet medially. One spine and five rays articulate with each basipterygium. In *Chalixodytes*, the ventral arm of the posttemporal is about $1/3$ the length of the dorsal one; five rays articulate with radials 3 and 4, seven with radials 1 and 2. The area separating the cleithrum from the coracoid is slightly larger. The cleithral shelf is confined to the upper half of that bone. One spine and four rays articulate with each basipterygium. The pelvic spur are larger and meet medially. The lower half of the supracleithrum is wide, the upper half tapered. The ventral arm of the posttemporal of *Apodocreedia* is about $1/4$ the length of the dorsal one. The degree of fusion between the cleithrum and coracoid and between the radial is greater; the cleithral shelf is rudimentary, confined to upper fourth of the bone. In this genus, the pectoral radials completely overlap one another and the pelvic fin is absent.

DISCUSSION

GOSLINE (1963) described several osteological characters for *Crystallodytes cookei* Fowler, 1923, some of which have been re-interpreted by NELSON (1985) as synapomorphies for the Creediidae. NELSON (1985), indicated that "the family Creediidae is a relative compact group whose species are quite distinct from all other families currently recognized in the heterogeneous suborder Trachinoidei" and suggested the monophyly of the group, based on a list of characters" most of

which probably derived, relative to other trachinoid groups”.

Our examination of the osteological characters of creediids has brought about new characters (described above) which can separate members of the Creediidae from other trachinoids. These are: dentary bone not completely toothed, anterior tip of urohyal lying on second or third basibranchial and posterior tip of mesopterygoid reaching posterior margin of skull. ROSA (1993), in a cladistic analysis of the Creediidae, has used these characters to support the monophyly of the group.

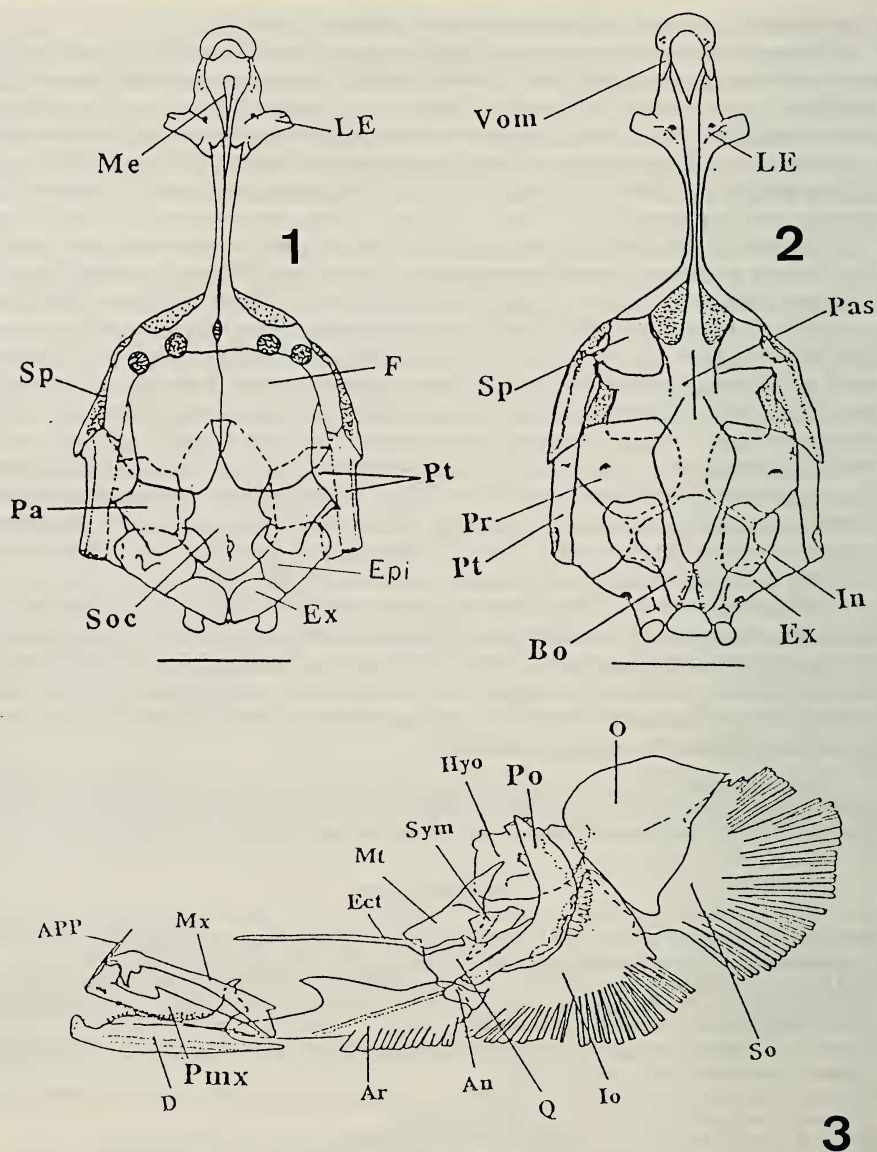
Regarding the creeid genera, *Schizochirus* can be characterized by the lacrymal with a median transverse groove, a large lateral flange on nasal bone (a small flange observed in *Hemerocoetes* Valenciennes, 1837) and anal pterygiophores with lateral flanges. NELSON (1985) mentioned that postcleithra were absent on creediids, except for *Schizochirus*; however, a rudimentary postcleithrum is present at least in *Creedia haswelli* (we could not be conclusive about this character in the other *Creedia* species). *Creedia* can be defined by the presence of less than 19 rays on dorsal fin and of a small projection on posterior end of lacrymal. *Apodocreedia* can be characterized by: pectoral rays completely overlapping each other, hypural plates completely fused and pelvic fin absent; *Chalixodytes* possesses a distally tapered supracleithrum, unique among creediids. No osteological characters exclusive to *Crystallodytes* were found. However, this genus can be characterized by having body scales only along lateral line (NELSON, 1985).

Limnichthys is a poorly defined genus (ROSA, 1993), characterized by intermediate stages of first dorsal pterygiophore condition (with two stubs) and of ascending process of premaxillae (almost meeting medially). *Tewara* can be characterized by having the central frontal pore much larger than lateral ones. However, the boundaries between this genus and *Limnichthys* are not well defined, and should be further examined.

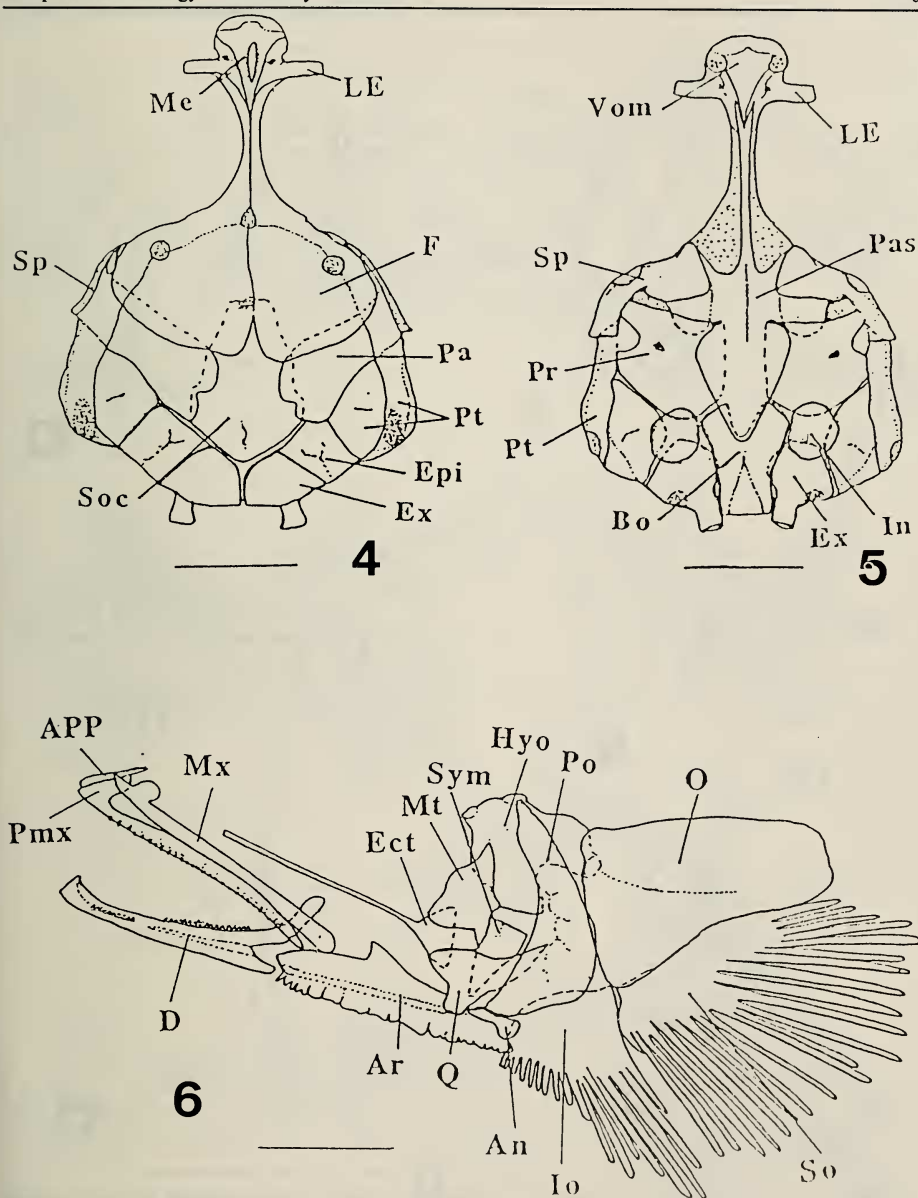
Acknowledgments. To my thesis supervisor, Dr. Joseph S. Nelson (University of Alberta, Canada) for all his help and encouragement; to Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), for providing financial support to this study (20.0819-87.9-ZO).

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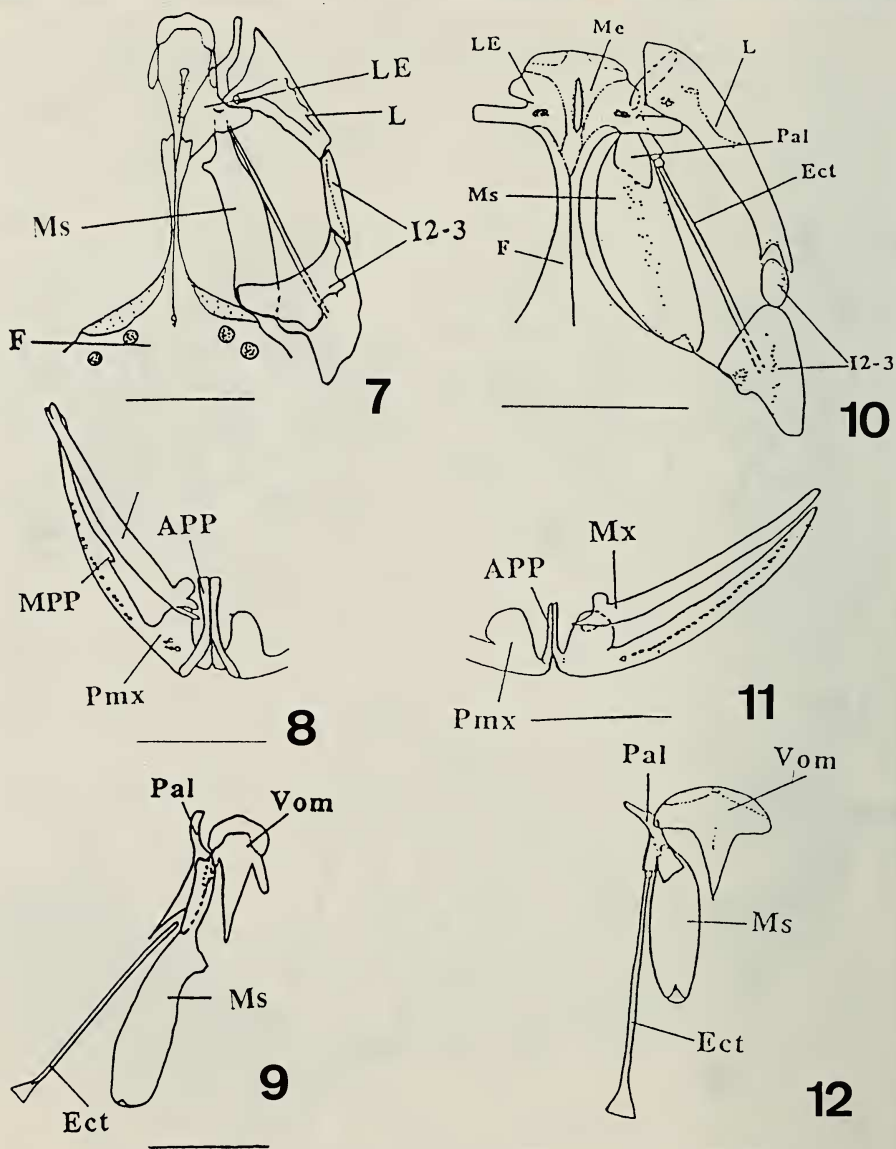
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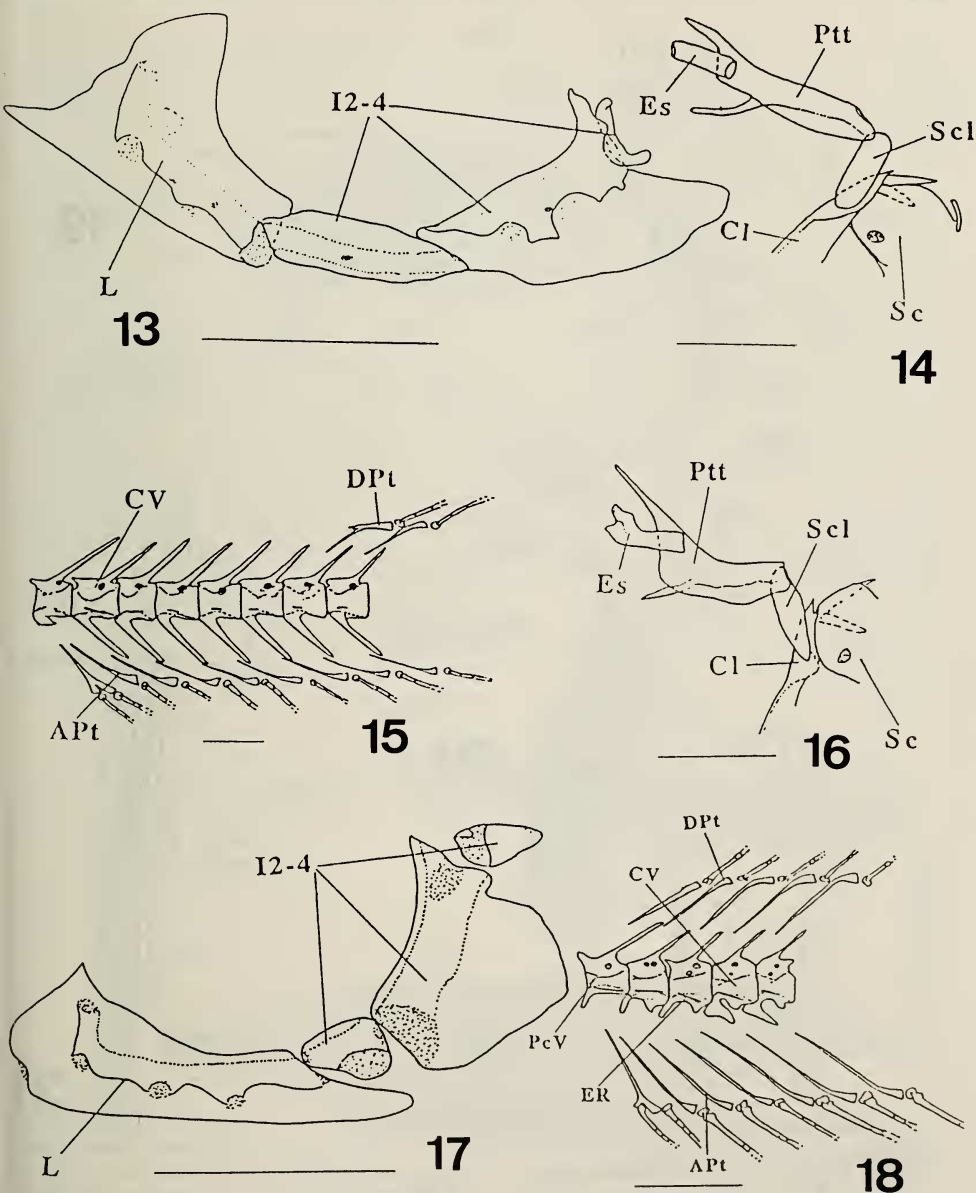
Figs. 1-3. 1, Skull of *Creedia haswelli*, dorsal view; 2, ventral view; 3, jaws, suspensorium and opercular apparatus; left lateral view. An, Angular; APP, Ascending Process of Premaxilla; Ar, Articular; Bo, Basioccipital; D, Dentary; Ect, Ectopterygoid; Epi, Epitotic; Ex, Exoccipital; F, Frontal; Hyo, Hyomandibular; In, Intercalar; Io, Interopercle; LE, Lateral Ethmoid; Me, Mesethmoid; Mt, Metapterygoid; Mx, Maxilla; O, Opercle; Pa, Parietal; Pas, Parasphenoid; Pmx, Premaxilla; Po, Preopercle; Pr, Prootic; Pt, Pterotic; Q, Quadrate; So, Subopercle; Soc, Supraoccipital; Sp, Sphenotic; Sym, Symplectic; Vom, Vomer; Bar = 1mm.



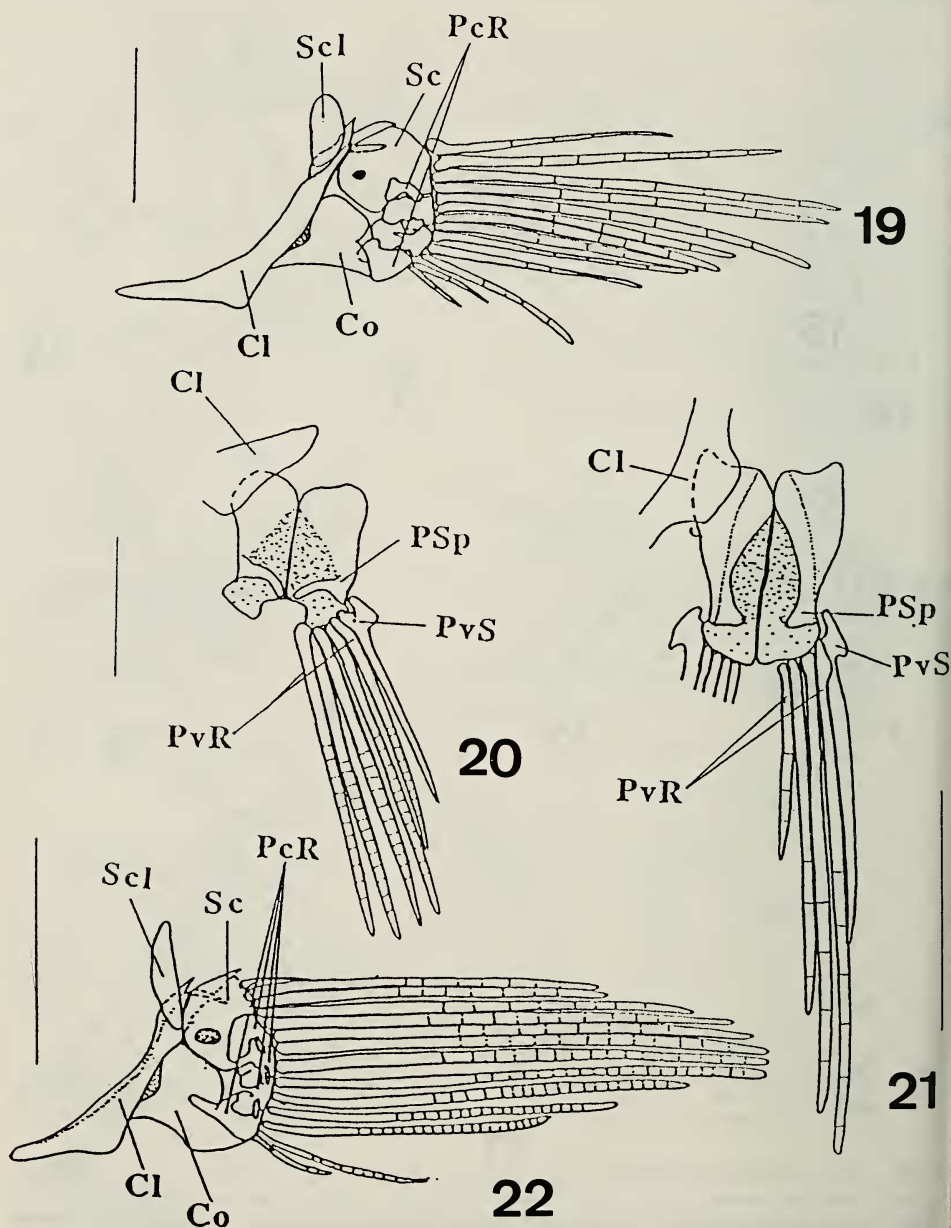
Figs. 4-6. 4, Skull of *Limnichthys fasciatus*, dorsal view; 5, ventral view; 6, jaws, suspensorium and opercular apparatus; left lateral view. An, Angular; APP, Ascending Process of Premaxilla; Ar, Articular; Bo, Basioccipital; D, Dentary; Ect, Ectopterygoid; Epi, Epiotic; Ex, Exoccipital; F, Frontal; Hyo, Hyomandibular; In, Intercalar; Io, Interopercle; LE, Lateral Ethmoid; Me, Mesethmoid; Mt, Metapterygoid; Mx, Maxilla; O, Opercle; Pa, Parietal; Pas, Parasphenoid; Pmx, Premaxilla; Po, Preopercle; Pr, Prootic; Pt, Pterotic; Q, Quadrate; So, Subopercle; Soc, Supraoccipital; Sp, Sphenotic; Sym, Symplectic; Vom, Vomer. Bar = 1mm.



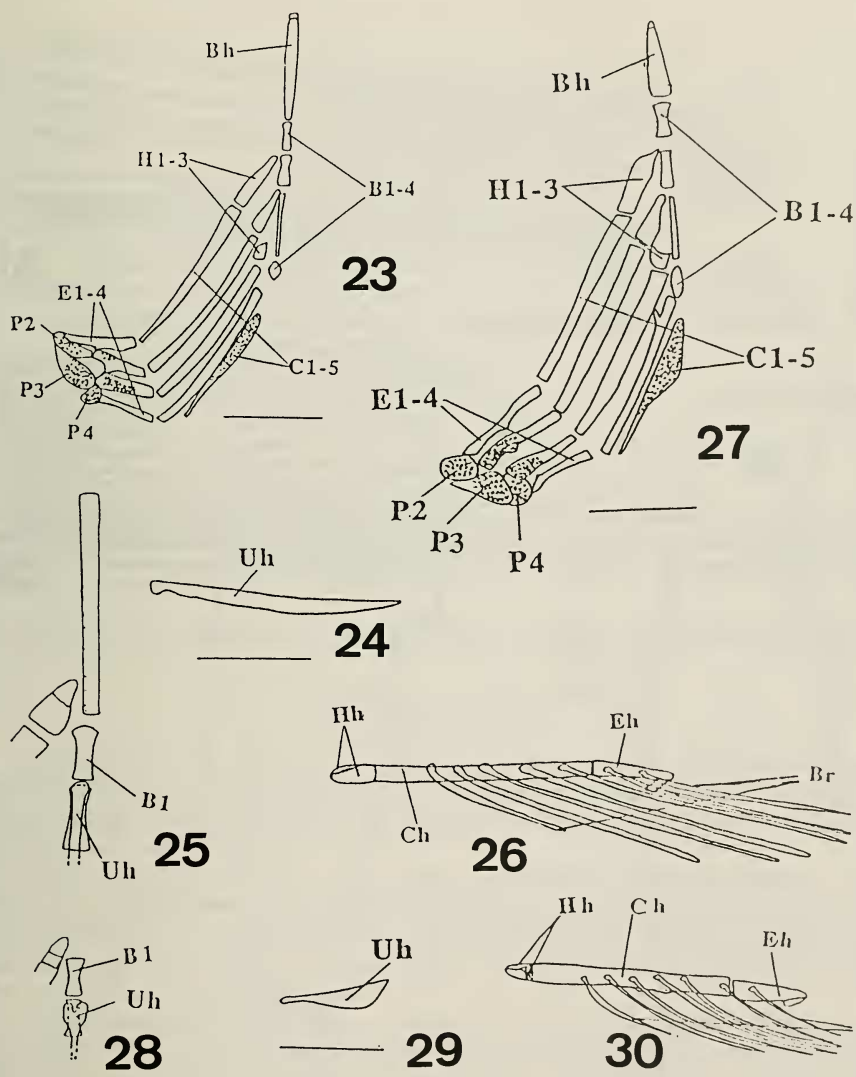
Figs. 7-12. *Creedia haswelli*: 7, dorsal view of anterior region of skull showing infraorbital series and mesopterygoid position; 8, upper jaw, dorsal view; 9, detail of the vomer and some bones of the suspensorium, dorsal view. *Limnichthys fasciatus*: 10, dorsal view of anterior region of skull showing infraorbital series and mesopterygoid position; 11, upper jaw, dorsal view; 12, detail of the vomer and some bones of the suspensorium, dorsal view. APP, Ascending process of premaxilla; Ect, Ectopterygoid; F, Frontal; I 2-3, Infraorbitals 2-3; L, Lacrymal; LE, Lateral Ethmoid; Me, Mesethmoid; MPP, Maxillary process of premaxilla; Ms, Mesopterygoid; Mx, Maxilla; Pal, Palatine; Pmx, Premaxilla; Vom, Vomer. Bar = 1 mm.



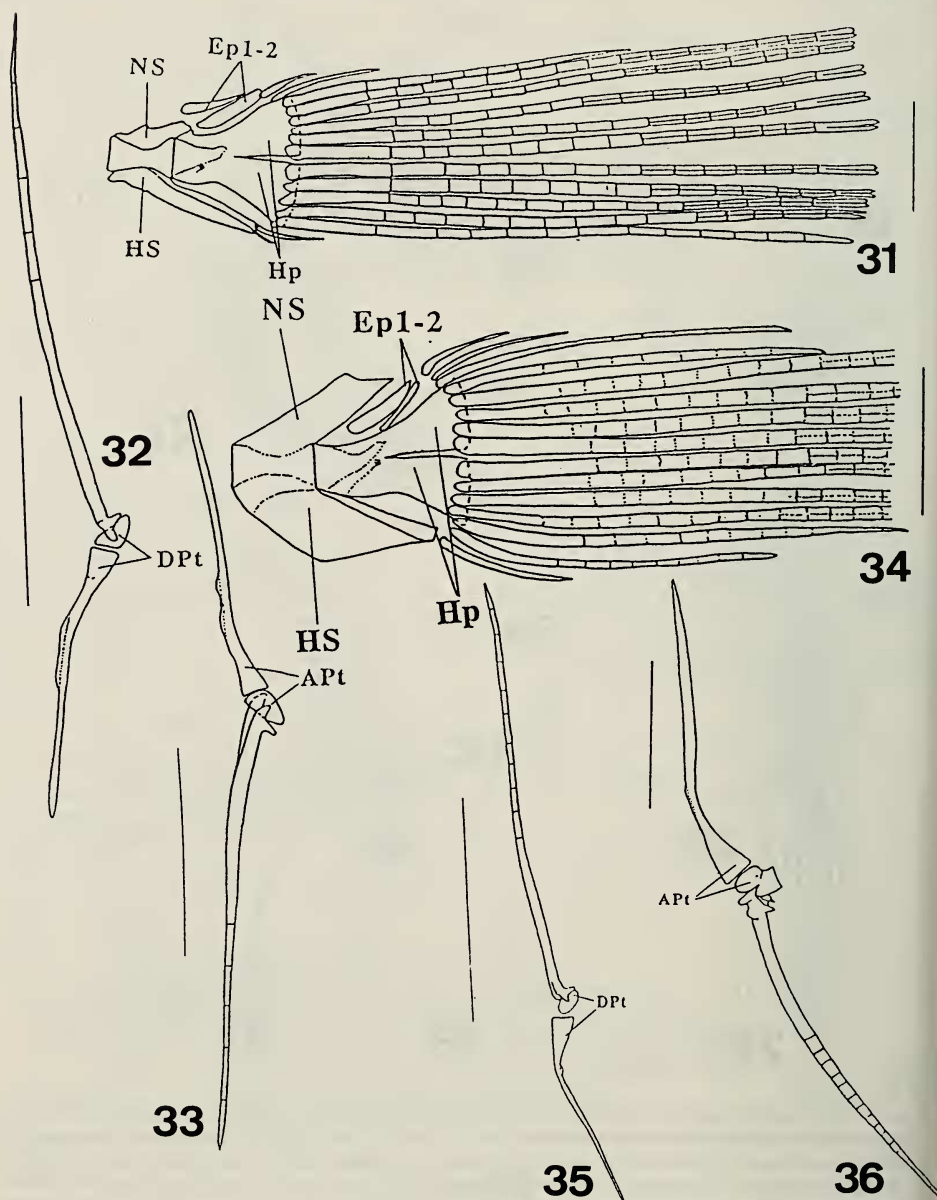
Figs. 13-18. *Creedia haswelli*: 13, left lateral view of the infraorbital series; 14, part of the pectoral girdle, lateral view; 15, part of the axial skeleton, lateral view. *Limnichthys fasciatus*: 16, part of the pectoral girdle, lateral view; 17, left lateral view of the infraorbital series; 18, part of the axial skeleton, lateral view. APt, Anal fin pterygiophore; Cl, Cleithrum; CV, Caudal; DPt, Dorsal fin pterygiophore; ER, Epipleural ribs; Es, Extrascapular; I 2-4, Infraorbitals 2-4; L, Lacrymal; PcV, Precaudal vertebra; Ptt, Posttemporal; Sc, Scapula; Scl, Supracleithrum. Bar = 1mm.



Figs. 19-22. 19, Pectoral skeleton of *Creedia haswelli*, lateral view; 20, Pelvic skeleton of *Limnichthys fasciatus*, ventral view; 21, Pelvic skeleton of *C. haswelli*; 22, Pectoral skeleton of *L. fasciatus*. Cl, Cleithrum; Co, Coracoid; PcR, Pectoral radials; PSp, Pelvic spur; PvR, Pelvic fin rays; PvS, Pelvic fin spine; Sc, Scapula; Scl, Supracleithrum. Bar = 1mm.



Figs. 23-30 *Creedia haswelli*: 23, branchial arches, left side, dorsal view of ventral surface. Epibranchials and pharingobranchials unfolded and shown in ventral view; 24, urohyal, lateral view; 25, diagrammatic representation of anterior end of urohyal, showing its position with respect to basibranchial; 26, diagrammatic representation of the hyoid apparatus. *Limnichthys fasciatus*: 27, branchial arches, left side, dorsal view of ventral surface. Epibranchials and pharingobranchials unfolded and shown in ventral view; 28, diagrammatic representation of anterior end of urohyal, showing its position with respect to basibranchial; 29, urohyal, lateral view; 30, diagrammatic representation of the hyoid apparatus. B1-4 - Basibranchials 1-4; Bh, Basihyal; Br, Branchiostegal rays; Ch, Ceratohyal; C1-5, Ceratobranchials 1-5; E1-4, Epibranchials 1-4; Eh, Epihyal; H1-3, Hypobranchials 1-3; Hh, Hypohyals; P2, P3, P4, Pharingobranchials 2,3 and 4; Uh, Urohyal. Bar = 1mm.



Figs. 31-36. *Creedia haswelli*: 31, caudal skeleton; 32, dorsal pterygiophore; 33, anal pterygiophore. *Limnichthys fasciatus*: 34, caudal skeleton; 35, dorsal pterygiophore; 36, anal pterygiophore; APt, anal pterygiophore; DPt, dorsal pterygiophore; Ep1-2, Epurals 1-2; Hp, Hypurals; HS, Haemal spine; NS, Neural spine. Bar = 1mm.